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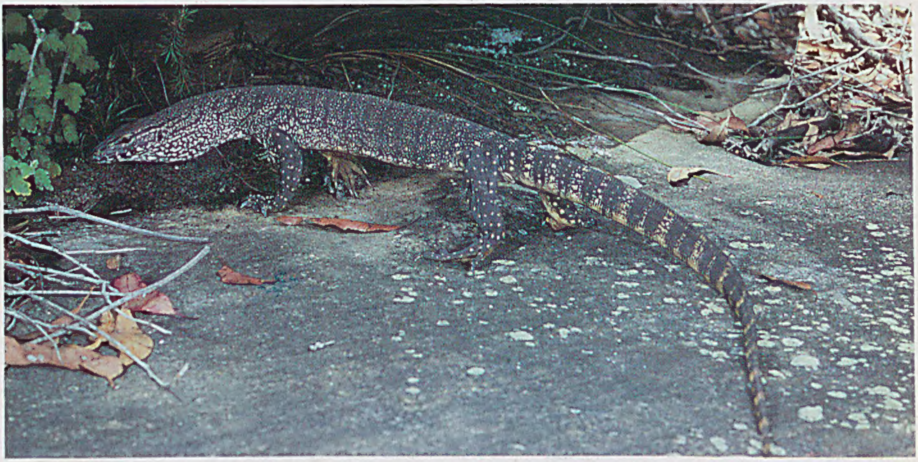
A female *Hypsilurus spinipes* from Mobong Falls, NSW.
This species is the subject of one of the articles in this issue.(photo A. Manning)



This Heath Monitor *(Varanus rosenbergi)* from the Darkes Forest area south of Sydney is in typical foraging stride with the neck arched and the gular region slightly distended in mild threat to the photographer. Note the finely patterned yet relatively dark dorsal colour and the tail's many characteristic narrow yellow bands especially towards its end.

This species is the subject of one of the articles in this issue. (photo H. Ehmann)

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THE ROLE OF THE AMATEUR HERPETOLOGIST IN WESTERN AUSTRALIA

D.Knowles, 26 Cook Street, Nedlands 6009.
B. Maryan, 169 Egina Street, Mt. Hawthorn 6016.
R. Browne-Cooper, 9 Rankin Road, Shenton Park 6008.

WITHOUT PREJUDICE

INTRODUCTION

In view of a recent court case involving Paul Orange, an amateur Herpetologist vs the Department of Conservation and Land Management (CALM), the authors felt it necessary to embark upon an objective discussion regarding the limitations of the current Wildlife Act and its implications on the future of amateur herpetology in this state. We define an amateur herpetologist as one who studies herpetology for the love of the subject and who is not academically qualified.

Our understanding of the cause for litigation is as follows:
In 1987 Paul Orange (amateur herpetologist) declared under amnesty to CALM his small collection of reptiles. He took this step in order to apply for a license to continue the maintenance of his collection. He had kept extensive and detailed notes of observations both in the field and in captivity, some of which have been published. Following his declaration Orange gave CALM Wildlife Officers access to his notes and permission to view his collection. He was assured by CALM Officers that it was to his benefit to do so and that they were assessing his ability to keep a reptile collection. Information contained in those notes disclosed that four geckos (two *Gehyra variegata* and two *Heteronotia binoei)* had been fed to the snakes in his possession.

On the 10 April 1990 he was advised in a letter from CALM that he would be granted a license to keep reptiles in captivity - and then at a later date he was prosecuted for feeding them these four geckos.

The two gecko species in question are ideal for feeding many lizard-eating snakes. Greer, A. 1989 (p 62) states:

> "*Heteronotia* is one of the most wide-spread and abundant gecko genera in Australia. It occurs throughout the continent except for the far south-western and south-eastern corners and can be incredibly abundant, especially in disturbed habitats such as rubbish tips. Indeed , when collecting in tips one sometimes gets the impression that there is at least one *Heteronotia* under every piece of ground cover, and it is axiomatic amongst reptile collectors that when nothing else is stirring one can always count on uncovering *Heteronotia*".

It is the opinion of the authors that *Gehyra variegata* is equally as common. This case poses the question: Is there any protection in law when declarations are made under amnesty? In the following we raise other questions, provide some amateur perspectives, outline the role of amateurs in W.A. and make some considered recommendations.

DISCUSSION

The late Dr Glen Storr of the WA Museum was one of the most productive members of the Australian herpetological community. Much of his great output would not have been achieved without contributions of specimens and field data by a small group of dedicated amateurs. Clearly government resources and funds are severely limited in many areas of biological research. These deficiencies are often overcome (usually at considerable personal expense) by the activities of self-motivated naturalists.

Western Australia has a large and diverse reptile fauna with half of the continent's species occurring within its borders. There are simply not enough professionals in our small population to effectively study important issues like conservation and ecology. At the recent first World Congress of Herpetology in England many professionals indicated clearly that their interest, and much of their early training, involved looking after "pet" amphibians and reptiles as children or young adults.This is more or less impossible in WA under the current Wildlife Act.

How Amateurs Contribute to the Advancement of Australian Herpetology

1. By providing specimens to institutions for study by professional herpetologists and biologists. A large number of specimens lodged in Australian museums were provided by amateurs who in the last 12 years have discovered the following new taxa in WA :-

   i) 55% of the large gecko genus *Diplodactylus.*
   ii) 25% of the legless lizards. No new species were discovered by professionals during this period.
   iii) 50% of Australia's largest reptile genus, the striped skinks *Ctenotus* spp.
   iv) 86% of WA's largest reptile genus, the burrowing skinks *Lerista* spp.

2. By the publication of articles in journals and magazines. In addition, the most comprehensive photographic reference work on Australia's reptiles was produced in 1988 by two amateur herpetologists - S Wilson and D Knowles.

3. Amateurs readily make their photographs available for use in publications and educational programmes. An example of this is the series of identification handbooks on amphibians and reptiles occurring in this state, produced by the WA Museum with grant money provided by Harry Butler.

4. By the voluntary capture and removal of dangerously venomous snakes from residential areas and their subsequent release into undisturbed bushland. This service is assisted by CALM.

5. An important contribution to public awareness is achieved through slide shows and general talks, often in combination with a display of live animals, and leading field excursions. Amateurs tirelessly endeavour to educate and promote a responsible attitude towards reptiles, offering the choice of developing "respect through understanding", or maintaining "fear through ignorance".

6. By conducting privately funded expeditions to poorly known and remote areas not normally visited by the small body of professionals. Amateurs also carry out both funded and un-funded surveys of vertebrates for museums, wildlife institutions, naturalists clubs and shires.

> We further quote from Dr Alan Greer's *Evolution and Biology of Australian Lizards:* "In gathering the material for this book, I have been impressed by two aspects of the current state of knowledge of Australian lizard biology, and indeed Australian herpetology in general. The first is the role of amateurs and the second is the amount of information still locked away in peoples' heads or in unpublished theses and reports. Amateurs have contributed substantially to the development of Australian herpetology, as will be evident from the references to their work in this book. Their importance derives primarily from their observations of live animals : captive specimens, a species seen during a field trip, or a local fauna. Unfortunately the role of amateurs in Australian herpetology is now under threat from certain state authorities. Rules and regulations make it increasingly difficult to observe or photograph native fauna. For many amateurs who are often too young to fight or have no affiliation with another, protective bureaucracy like a museum or university, this means giving up or going "underground". As a result much opportunity for knowledge and personal development through investigation, discovery and discussion is lost".

Weigel (1988) also states that the attitude of the Western Australian government towards amateur herpetology differs significantly from all other Australian States and Territories and that enquiring hobbyists should be aware that the detection and prosecution of unlicensed keepers is rigorously pursued by CALM. To our knowledge, only three amateur herpetologists are legally entitled to keep reptiles in the entire Perth region - a population of one million people. We believe that parts of the Act that cover protection of fauna were poorly written by people who had limited knowledge of the subject. It is clear that there are many unforeseen implications which more or less completely outlaw an amateur's active interest in herpetology. This results in the following scenarios :

1. As is the case in any field of interest, over-control results in no control, which therefore leads to the loss of information from those amateurs who have been forced through fear of prosecution to go "underground". Potentially valuable members of the herpetological community are sometimes forced underground as a result of "out of hand" rejection of a formal legal application to keep fauna for educational or study purposes.

2. Wildlife officers trained to enforce this draconian Act often fall into the trap of having to justify their position by directing their attempted convictions at responsible "known" naturalists, rather than those "unknown" and difficult to detect criminal elements. Wildlife officers need to develop skills to enable them to detect the "unknown", rather than monitor the "known". Close liaison with detectives in the WA Police Force would undoubtedly increase their ability to apprehend real offenders. A number of classic examples of attempted convictions by CALM against innocent (but ignorant of the new law) naturalists have ended up in court with the outcome of CALM losing. WHY? Because the prosecuting officers did not properly investigate the subject by tracing reputation, eg ringing the local museum, zoo etc.

3. Wildlife officers also tend to over-scrutinise existing permit holders in order to further justify their enforcement activities. This leads to the permit holder continually feeling that the enforcers don't trust them- a situation that does not promote mutual respect. Surely the time wasted pursuing dedicated and licensed amateurs could be better spent seeking out any real offenders.

4. This state has produced one of Australia's foremost herpetologists, Dr Glen Storr. We strongly doubt that within the framework of the existing Act there is room for a new generation of both non-professional and professional herpetologists.

Both city and country children with a keen interest in frogs and reptiles are continually confronted with the destruction of habitats by developers, miners and farmers. They realise that many thousands of their favourite animals perish in the name of "progress". How is it, they wonder, that adults can destroy so many amphibians and reptiles, and they are not allowed to keep a tree frog or a Bobtail skink so that they may learn about it?
Why does the Act not cater for the encouragement of an active interest which in the long run is the essence of community awareness about nature conservation?

A Suggested Philosophical Change to the Act

Recognition of the fact that the interests of non-professional and professional herpetologists usually stem from childhood. Amateurs can and will make valuable contributions to the knowledge and understanding of herpetology in Australia. The Act should be re-structured in such a way to allow this to occur.

NB: The amalgamation between the Fisheries and Wildlife and the Forestry Departments in Western Australia was originally motivated by political and economic considerations. This reflects a conflict of interests - development vs conservation.

The implications of an amended Act would accommodate amateur herpetologists in the following ways :-

1. By establishing a more positive working relationship between the new department and amateur herpetologists.

2. Given foreseeable budgetary restraints on government departments in general, field survey work must correspondingly decrease. If encouraged, certified amateurs could make up this shortfall. Ongoing survey work may have to be discontinued in various areas - eg pit-trapping programmes. Amateurs should be encouraged to re-open existing traplines, thus adding valuable seasonal information. In the case of pit-trapping practices, amateur herpetologists should recognise the need to collect representatives of all material trapped. For example, mammalogists, entomologists and arachnologists should be informed of the programme as a matter of course, and vice versa.

3. Some amateurs would be very interested in breeding rare and endangered reptile fauna. This is another area where the resources of CALM are limited. Captive breeding programmes could be designed,and supervised by professional scientists, to involve amateurs, whether it be by collecting, monitoring or breeding. For example, the threatened Lancelin Island Striped Skink *Ctenotus lancelini*, the Lined Burrowing Skink *Lerista lineata*, and the south-western populations of the Woma Python *Aspidites ramsayi* could benefit by such programmes.

4. With the implementation of an "amateur-friendly" system those people who keep reptiles illegally would, under amnesty, make themselves known. Consequently their experiences would be shared.

5. Once the amateur herpetological community is quantifiable objectives and bona-fides can then be defined and confirmed. This would naturally lead to the formation of an amateur herpetological group which would encourage keeping standards, oversee captive breeding programmes, recruitment of responsible new members and the dissemination of information through informal and formal avenues. Exempt lists would be co-operatively prepared. A protocol of interaction should be established between the governing body and the licensed amateurs. For example, inspection of legally-maintained collections should be arranged by appointment.

6. The new department should employ, or train, officer(s) competent in reptile husbandry techniques.

CONCLUSION

Given the opportunity, there is potential for a quantum leap in co-operation and dissemination of knowledge of herpetology in Western Australia. The authors hope that this discussion will be seriously considered both by CALM and the readers of this journal. There is an obvious need for review of the abovementioned issues in the light of co-operative achievements of amateurs, professionals and wildlife authorities in the eastern states.

On the 16th November, 1990 a magistrate in the Kalgoorlie courts dismissed all four charges against Paul Orange and awarded the maximum available costs to him.

ACKNOWLEDGMENTS

The authors would like to express their thanks to Mrs Ros Goulding for her assistance in manuscript preparation.

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A STUDY OF THE ACTIVITY AND BEHAVIOUR OF THE SOUTHERN ANGLE-HEADED DRAGON USING THE SPOOL TRACKING TECHNIQUE.

Alan Manning,
Department of Veterinary Clinical Sciences,
University of Sydney, 2006.

Harald Ehmann,
School of Biological Sciences,
Sydney Technical College, Broadway, 2007.

ABSTRACT

A three month study of Southern Angle-headed Dragons *Hypsilurus spinipes* by using the spool tracking technique yielded a wide range of data that would have been difficult to obtain using standard location or catch release methods.

Data indicate that *Hypsilurus spinipes* prefers a closed forest habitat with access to open areas for basking. Males forage in the leaf litter for worms and insects. The 24 data points for 10 individuals indicate that the preferred activity temperature range is 17.8° to 25.1°C mean 21.7°C, this is significantly lower than for other species of agamid lizards. Sleep sites are always elevated, either in saplings or on vines of between 15 and 95 mm diameter. These agamids prefer to climb saplings, young trees and vines of between 20 and 60mm in diameter.

Female coloration is more cryptic than males, its main features being alternating barring on the sides of the head, and "eye-lash" type markings in females. Implications for the conservation of this species are discussed.

INTRODUCTION

The Southern Angle-headed or rainforest Dragon *(Hypsilurus spinipes)* is one of two species of the genus *Hypsilurus* (formerly *Gonocephalus*) occurring in Australia.

Hypsilurus spinipes is habitat specific (Webb 1984) being restricted to isolated pockets of wet sclerophyll forest and rainforest on the coastal side of the Great Dividing Range between Gympie in the north and Gosford in the south. Specimens are difficult to locate in the field because their coloration, profile and stance provide excellent disruptive camouflage. The habit of moving to the opposite side of a sapling (Bevan 1983) also makes the dragons difficult to locate.

Between December 1989 and April 1990 searches for *Hypsilurus spinipes* were carried out in forest areas around Coffs Harbour, NSW. Forestry Commission forest maps were used to locate areas of rainforest, and I, (A.M.), searched in areas where I had previously encountered *Hypsilurus spinipes* during 1975-78. These areas included Bruxner Park Flora Reserve, Orara East, Orara West and Clouds Creek State Forests. While each of these named areas had what appeared to be ideal habitat, no specimens were found.

On the 6th of January 1990 a single adult male was located in Wild Cattle Creek State Forest (30° 10'S 152° 47'E) 10km N.E. of Cascade. Subsequent searches of the surrounding area over the next three weeks yielded a further 8 individuals. Another adult male was located in Wild Cattle Creek State Forest on Cedar Road (30° 12 ' S 152° 44 ' 30 " E) but searches failed to locate any more individuals. During March 1990 I carried out more field work. On this trip a total of 7 dragons were found (2 of these had been studied during January).

Spooling techniques have been extensively developed by one of us (H.E) over the last five years. To date it has been adapted for and used on small to large mammals, birds, small lizards (including fossorial species such as *Saiphos equalis*), medium and large lizards (eg. *Varanus ssp, Pogona ssp*) as well as medium to large snakes and large frogs. Spool tracking is routinely used in teaching the Herpetological Techniques Course and other field ecology subjects at the Sydney Technical College (Biological Sciences). The value of the spool tracking technique can be gauged from the major findings of this study.

MATERIALS AND METHODS

When first located, the body temperature of each dragon was measured by placing a thermistor probe on the side of the forebody. Some individuals tolerated this process without restraint while others were restrained by gripping the mid-tail.

The time, substrate temperature and air temperature (at 1 metre above ground) were also recorded.

Standard data was recorded (see Table 1) and the ventral surface marked with Tippex or Liquid Paper to allow for positive identification if later recaptured, A spool of fine nylon thread (2 grams, approximately 250 metres) was attached to the base of the tail just caudad from the cloaca with paper-based surgical tape (3M Micropore). The white tape was discoloured and disguised with waterproof black felt pen and then smeared with mud or clay. Each dragon was then released at the capture site within 3-5 minutes after capture. After a variable time the thread was traced, measured, interpreted for activity (eg basking, scratching) and where possible the dragon was located and observed with minimal interference. At the end of each day the total distance travelled was measured and if less than the daily average of thread discharge was not left in the spool, the dragon was recaptured and fitted with a replacement spool.
On the March field trip I used a hide to make more detailed behavioral observations.

Table 1. Morphological Data for Specimens found in this Study

#	SEX	MATURITY	SVL	TAIL LENGTH (mm)	WEIGHT (g)	NOTES
1	M	Adult	105	227	59	Sloughing (6/1/90)
2	M	Adult	110	250	71	Sloughing (9/1/90)
3	M	Adult	110	245	62.5	Mites around eyes & neck (10/1/90)
			110	247	53	Mites on neck only (18/3/90)
4	M	Adult	113	118	66	Sloughing (10/1/90) end or part of tail missing.
5	M	Adult	108	220	52.5	Sloughing (12/1/90) mites around right eye and neck. Bite wounds caudad to cloaca.
			109	224	60	Mites right eye (20/3/90) mucus right nostril. Bite wounds neck (dead tissue) and scars at previous bite site.
6	M	Sub-Adult	101	217	46	Different coloration to adult males, with labial stripes (14/1/90) Mites around neck (17/1/90)
7	F	Adult	103	220	48	Sloughing Mottled appearance labial & lateral stripes.

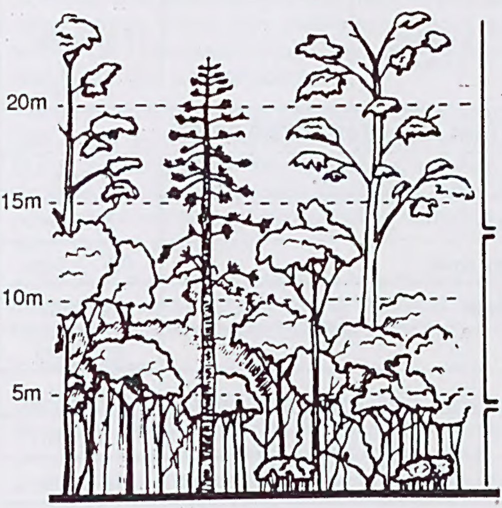
8	F	Adult	105	216	49	Similar appearance to #7, no mites (17/1/90)
9	F	Adult	110	217	59	Mites right eye (17/3/90) Mottled coloration as #7.
10	M	Adult	110	251	62	Mites left eye and neck. Scars on dewlap LHS and caudad to cloaca RHS (17/3/90).
11	M	Adult	103	239	50	3 teeth missing maxilla, 1 tooth missing dentary. Bite scars front dewlap (19/3/90)
12	F	Adult	103	215	58	Mites right eye)20/3/90). Mottled appearance. Vertical labial stripes.
13	?	Juvenile	79	152	20	Red/brown colour (20/3/90). Vertical labial stripes.

RESULTS AND DISCUSSION

1. Habitat and Feeding

The habitat where most of the dragons were observed was a small isolated pocket of warm temperate rainforest/ wet sclerophyll forest. The area had been selectively logged in 1974-75, and consisted of a sparse canopy (predominately of mature seed trees) and a dense fairly uniform understory with slender (4-12cm) regrowth tree trunks, frequently covered with mosses, lichens and orchids. Vines and undergrowth shrubs were common between the understorey and ground (see Figure 1 for predominate plant species). The forest floor was reasonably clear of vegetation, with a dense covering of leaf litter (2-8cm). During January the leaf litter contained high numbers of insects (mainly coleoptera) and earthworms, (See Table 2), while during March there were lower numbers of insects in the leaf litter and the most abundant insects were grasshoppers and butterflies on and over the litter.

The area of suitable habitat was surrounded by a dry sclerophyll forest (predominantly Blackbutt, Ironbark and Grey gum) with no understorey. This area had been extensively



CANOPY

Coachwood - *Ceratopetalum apetalum*
Blackbutt - *Eucalyptus pilularis*
Hoop Pine - *Araucaria cunninghamii*
Sassafras - *Daryphora sassafras*
Crabapple - *Schisomeria ovata*
Turpentine - *Syncarpia glomulifera*

UNDERSTOREY

Turpentine - *Syncarpia glomulifera*
Crabapple - *Schisomeria ovata*
Blackwood - *Acacia melanoxylon*
Forest Oak - *Allocasaurina torulosa*
Vines and Epiphytes

GROUND

Tree Heath - *Trochocarpa laurina*
5 Leaf Water Vine - *Cissus hypoglauca*
Ground orchids and grasses

Figure 1. Forest Transect and Species List for Study Site

fire-affected 6-8 months previous (per obs) and regrowth of grasses and seedlings was plentiful. The leaf litter was thin (0-2 mm).

Three adult males were observed from the hide eating earthworms, coleopterans and grass-hoppers. A sub adult male ate an earthworm.

Two males ventured briefly into the adjoining dry sclerophyll habitat. One excursion was for foraging and possibly basking, as there were many scratch sites and a couple of possible basking sites. The other male returned to the moister habitat and his territory directly after scratching in the leaf litter.
It seems that all available suitable habitat was utilised by the study colony.

Tangled piles of logs from forestry practices are common and are utilised by *H.spinipes* for basking (as the understorey is usually thinner at these sites) and as elevated viewing and display platforms (per obs).

The dragon located at Cedar Road was in a narrow band of wet sclerophyll forest (20 metres deep) which was bordered by the road on one side and a eucalypt plantation on the other side. The leaf litter in this area was thin (0.5-1 cm) and grasses had started to colonise the roadside. No insect searches were carried out in this area.

Table 2. Invertebrates larger than 2mm located in leaf litter

SAMPLE QUADRAT	DATE 1990	INSECTS	ARACHNIDS	EARTHWORMS	OTHER
1	12/1	1 scarabid	-	1	6 leeches
2	14/1	1 cockroach 1 carabid 1 passalid 7 scarabid	-	2	6 leeches
3	17/1	-	-	-	-
4	17/1	1 cockroach	1 tick	1	3 leeches
5	17/1	2 cockroach 1 scarabid	-	1	-
6	18/3	termites	1 spider	-	1 millipede
7	18/3	-	1 mite	-	-
8	18/3	-	-	-	1 leech

QUADRAT DESCRIPTION AND LEAF LITTER DEPTH	
1 Wet Sclerophyll forest fringe	1-2cm
2 Wet Sclerophyll forest centre near logs	8-10cm
3 Dry Sclerophyll forest 5m from canopy cover	0.5 - 1.5cm
4 Wet Sclerophyll forest near undergrowth	2-3cm
5 Dry Sclerophyll forest fire affected	0 - 0.5cm
6 Wet Sclerophyll forest near logs	6-8cm
7 Wet Sclerophyll forest fringe	1-2cm
8 Check of site 2 at a later date	8-10cm

Quadrats were 1m^2 and representative of the habitats in the study area.

2. Movement and Territoriality

The movement of male and female *H.spinipes* is cautious, consisting of short runs interspersed by pauses during which the surrounding area is surveyed prior to moving on.

During January lacerations were observed on an adult male dragon (See Table 1, specimen 5) The shape and size of these injuries suggested that they were inflicted by another dragon. To assess male aggression, (during the March field trip) an adult male was placed in another male's area and released approximately 1 metre from the resident male (addition test). Within a minute of release the dragons were displaying with head bobs, extending dewlaps, raising bodies off the substrate, mouth gaping and tilting bodies towards each other. Two minutes later the added male was attacked and bitten around the dewlap area, and the two males tumbled over each other until the added male broke free (5-8 seconds after the attack). He consequently ran off pursued by the resident male who stopped the chase within 2 metres of his area's known boundary. The added male was then recaptured and after checking for injuries, released back in his own area.

During March a further 2 adult males were found with lacerations(refer Table 1, specimen 10 and 11). The data suggests that male aggression could occur all year, not just in the breeding season (Worrell 1963).

The spooling data is mapped for specimens 1,2,3,5 in Figure 2. There was a corridor 1-6 metres wide between individual males spool trails. During the study period no male spool lines crossed. The two males relocated in March, used the same central area but the outer boundaries shifted slightly. Thus the boundaries as indicated by the area enclosing each male's spool lines may have changed during the three month study period. Spooling and the addition test indicate that adult males are territorial. Territories ranged in size from approximately 300m^2 to 700m^2.

One male (#1) was not relocated on subsequent trips but was thought to be maintaining approximately the same territory as no other male ventured into this area. Although occasional rustling noises were heard from this area several searches failed to locate him.

The males discharged much of their spools by movement on the ground rather than in aboreal movement (Table 3). (Aboreal movement in this study includes movement on or along logs more than 8cm above the ground.) There was increased aboreal activity near the edge of each males territory, where they usually ascended a sapling or vine (generally not higher than 1 metre). On 17 occasions males were observed to display and then survey the surrounding area from these vantage points.

Females discharged less of their spools on the ground than males (See Table 3). Females may feed off the ground as no signs of leaf litter scratching was associated with their spool trails. During the study period they moved through male territories unharassed. Males sometimes displayed to the females with head bobs. After the display both animals moved off independently. Females may also establish territories as no female spool lines ever crossed or came close to each other.

A sub adult male was displayed at by a mature male while he was in the male's territory. The display was similar to the display of males towards females. There was no consequent harassment (as interpreted from the spool trail).

3. Sleep Sites

Sleep sites were scored for 30 nights (the Data is summarised in Fig.3). The vegetation of the study site contained species with almost horizontal branches and vertical stems, when the sleep site was on a vine it was taken either vertical or horizontal depending on the angle. Sleeping postures were reasonably consistent in the vertical position but varied in the

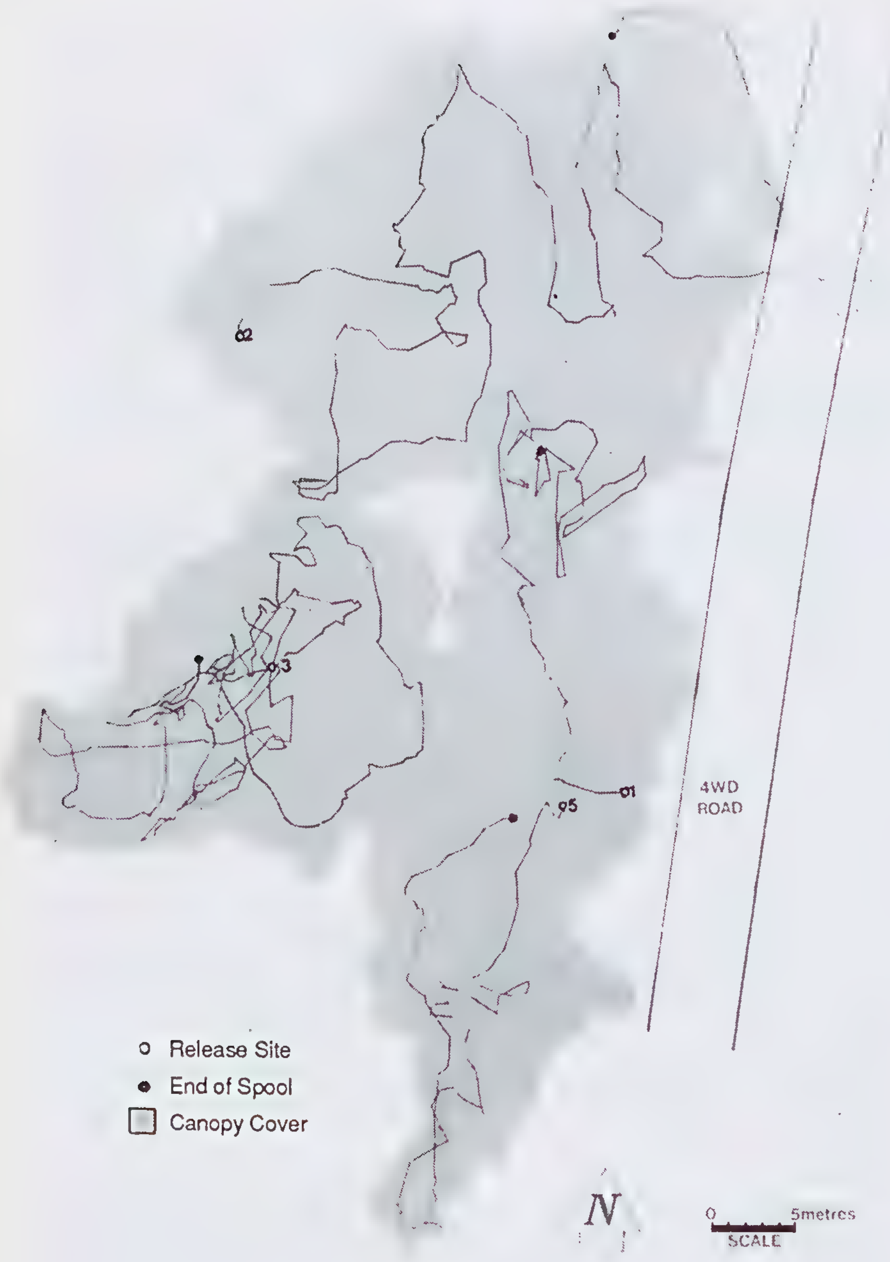


Figure 2. Male Spool Trails For January 1990

Table 3. Ground and Arboreal Activity of *Hypsilurus spinipes*

SPECIMEN	SEX	DATES 1990	METRES OF SPOOL ON GROUND	TOTAL	%ACTIVITY ON GROUND
1	M	7-9/ 1	60.40	104.36	57.8
2	M	10-15/ 1	187.01	256.42	72.3
3	M	11-18/ 1	217.85	295.36	73.7
3		18-22/ 3	57.3	68.3	74.1
4	M	12-17/ 1	50.45	83.5	60.4
5	M	13-17/ 1	83.58	122.33	68.3
5		20-22/ 3	48.8	68.45	71.3
6	Juv. M	15-17/ 1	14.3	34.65	41.2
7	F	17-18/ 1	20.3	74.85	27.1
8	F	18-19/ 1	5.0	22.5	22.2
9	F	17-23/ 3	35.0	80.6	43.4
10	M	17-23/ 3	116.75	192.75	60.5
11	M	19-23/ 3	79.45	125.75	63.2
12	F	21-23/ 3	18.6	39.9	46.6

$$\% = \frac{\text{number of metres on the ground}}{\text{total metres from spool}}$$

horizontal position from clutching the branch with all four legs to legs dangling with only one ventral surface in contact with the branch (pers obs).Sleep sites for males in this study were saplings or vines, there was no evidence of a fixed sleep site. Sleep site heights for males were an average of 2.6 metres and range from 1.5 to 8 metres (23 observations). Sleep sites for females were an average height of 3.0 metres and range from 0.9 to 4.7 metres (7 observations).
H.spinipes have no clear preference for a horizontal or vertical orientation during sleep.

No individuals were observed sleeping on top of each other or in communal groups as related by Longley (1943): that observation was probably related to close confinement or lack of enough elevated sleep sites in captivity.

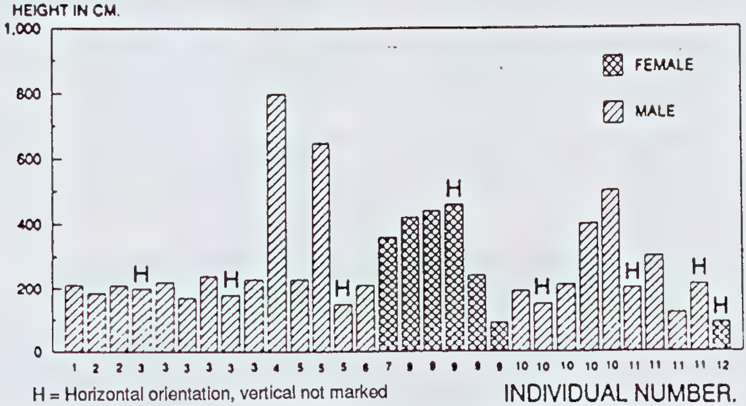


Figure 3. Sleep Site Heights and Orientation for *H.spinipes*

4. Body and Activity Temperatures

Temperature readings of active forest dragons were taken randomly between normal activity times (07.30-19.30 hours) over a wide range of environmental conditions (eg. raining, overcast and bright sunny days). Only two males were observed basking, but spool interpretation indicated a large number of possible basking sites. the temperature of the dragons was quite often above either air or substrate temperature (see Fig.4).

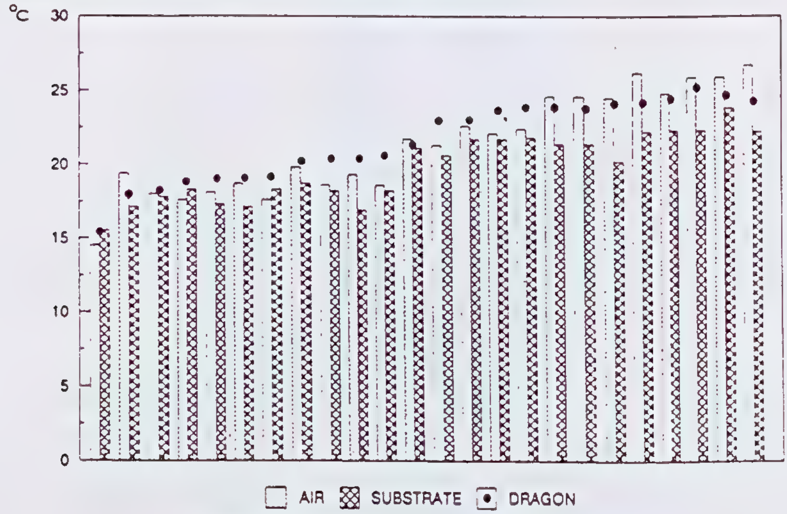


Figure 4. Field Temperatures of *H.spinipes*

Thermoregulatory behaviour by females was not observed but possible basking sites were interpreted along the spool trails.

The temperature range in which *H.spinipes* was active in this study was 15.5°C to 25.1°C compared to 25.2°C - 39.7°C for *Pogona barbata* (Heatwole 1976). Specimens of *H.spinipes* are reluctant to move in air temperatures below 17°C, but even then they are still capable of running or climbing to escape (pers obs). Thermoregulation by *H.spinipes* included basking and thigmothermic behaviour with adult males observed supporting their body close to or away from the substrate (pers obs). Thus *Hypsiluus spinipes* has a low preferred body temperature range when compared to other agamids.

There is no apparent relationship between the air temperature and the total number of metres travelled by each dragon. On cool days in March some individuals only move a couple of metres while others travelled up to 30 metres.

5. Tree Diameter Preferences

The spool trails frequently indicated that a dragon had ascended or descended a tree, vine or sapling. The species of plant was noted as was its diameter at a height of 1.2 metres from the ground. These diameters are summarised in Figure 5.

In the study area *Hypsilurus spinipes* preferred saplings and vines between 20 and 60mm in diameter. This size sapling (or vine) facilitates grip while climbing and also provides a very wide field of vision. The possible relationship between forest regrowth and sapling utilisation by *Hypsilurus spinipes* needs further research.

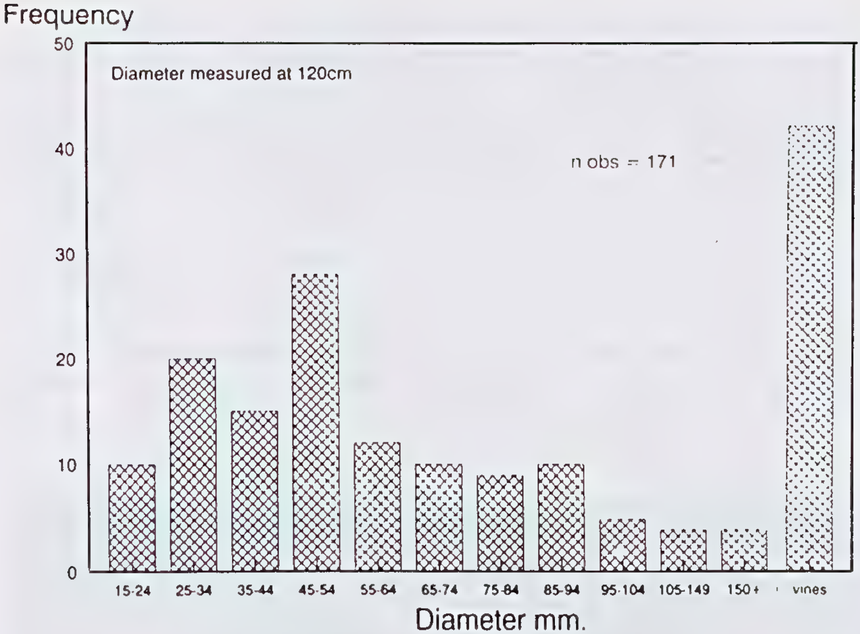


Figure 5. Tree Diameter Preferences of *H.spinipes*

6. Coloration

During the course of field work differences in the coloration of individuals were seen. Sexual dimorphism does not appear to occur in *Hypsilurus spinipes* as both males and females have similar snout-vent and tail lengths (Table 1), and similar sized dewlap and nuchal crests. However, the small sample size of this study indicates that sexual dichromatism may occur with the predominate feature being the presence of vertical labial stripes in females and juveniles (Figure 6.1 and 6.2) while adult males (Figure 6.3) apparently lack labial stripes. Both adult and juvenile females also have distinctive dark eyelash-like lines radiating upwards from the eye onto the supra-ocular skin. Dissections of museum preserves indicates that the individuals with labial stripes are females or sub adult males while those without were adult males (Shea, pers comm.).

Males generally have a more uniform body coloration while females tend to have blotchy coloration. Juveniles may have either uniform or blotchy coloration.

7. Spooling - Advantages and Disadvantages

Spooling enables the movement path of each individual to be monitored on a daily or, if required, more frequent basis. Spooling is an ideal method for monitoring the movement of a terrestrial/aboreal species like *Hypsilurus spinipes* as it provides precise witness of daily activities (eg. basking, foraging, territorial boundaries) albeit after the events.

There were limitations to the spooling technique. During periods of rain the spool pack became water-logged and the paper based tape tended to break down quickly (12-24 hours) in damp conditions. This enabled the dragon to shed the spool pack. Another uncertainty was in

predicting when the spool pack would run out. Daily tallies of distance travelled was not a reliable indicator as some days one dragon moved little (2.4m) and the next day it could travel up to 80 metres. Rapid relocation of a specimen and re-spooling was not easy to achieve with such a cryptic species and while working within strict time constraints.

A major problem with the technique was assessing the time at which thread witnessed events occurred. This can be partially overcome by following the spool trail at a specific time until the individual is observed and then recording the time and point. However (and partially with *Hypsilurus spinipes*) normal behaviour and activity ceases for variable and sometimes long periods of time (see Table 4) after interruption.

Despite its limitations the spool tracking technique can be used to obtain high quality and quantity data for several aspects of natural history which are otherwise difficult to study.

Table 4. Time Interval between Interuption and Normal Behaviour

DRAGON	DATE	TIME (min)	NOTES
3	19.3.90	18	
	19.3.90	32	
10	20.3.90	47	
	20.3.90	23	
	20.3.90	60+	Had only moved 1m 110mins later
	21.9.90	27	
	21.9.90	36+	Hide relocated for aggression test

A hide was placed in a male's territory and left for one day before observations commenced. The times between entering the hide and resumption of normal behaviour by the individual was then recorded

8. Implications for the Conservation of *Hypsilurus Spinipes*

The Southern Angle-headed Dragon *Hypsilurus spinipes* is listed under Schedule 12 part 3 of the Fauna Act (1984) as threatened fauna. The numbers of *H.spinipes* encountered would tend to indicate that they are locally common within specific vegetation types.

This study shows that *H.spinipes* prefers closed vegetation with slender uniform saplings and fringing open areas. This suggests that the species may rely on specific growth (and regrowth) stages of closed forest vegetation.

To arrive at an adequate conservation strategy further research is required before any conclusions can be drawn regarding habitat preferences, population sizes and minimum area required to support a population.

ACKNOWLEDGMENTS

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Figure 6.1 Female *H.spinipes*

Figure 6.2 Juvenile *H.spinipes*

Figure 6.3 Adult Male *H.spinipes* Eating Grasshopper

NESTING, EGG INCUBATION AND HATCHING BY THE HEATH MONITOR *VARANUS ROSENBERGI* IN A TERMITE MOUND.

Harald Ehmann, School of Biological Sciences,
Sydney Technical College,
1 Mary Ann St Ultimo 2007

Gerry Swan, 94 Yarrabung Road, St Ives 2075

Geoff Swan, 94 Yarrabung Road, St Ives 2075 and

Brendan Smith, Kitchener St. St Ives 2075.

ABSTRACT

Aspects of at least three nestings by the Heath Monitor in a termite mound near Sydney were observed between 1988 and early 1991. A system was developed to measure temperature, carbon dioxide (CO_2) and humidity in the vicinity of the eggs, and also to provide early warning of the hatching.

The female(s) dug narrow nesting burrows through the upper side of the termite nest (where its compacted zone is weakest) into the flaky deep core of the mound. Between three and four eggs were laid each time and these were partly covered with soil by the female(s). The termites entombed the eggs in the mound's core where temperatures remained in the range of 33.3 to 38.6°C all year. The parent(s) remained in the vicinity of the mound for 2 to 3 weeks, possibly to protect the nest. Development was complete within five months of oviposition at which time one embryo was tightly compacted within the entombed egg. Carbo dioxide levels were high (9670 to 14000°microlitres/ millilitre) as was humidity (never below 92%).

Not one of the three laid clutches (9 eggs) emerged as hatchlings; in each case the embryos died within their egg cases. It is concluded that the hatchling monitors are probably liberated by a nesting female or a tending parent.

The wide variation in hatching times published for some Australian reptile eggs may be due to the retarding effect of high CO_2/low O_2 concentrations. The effect of altered CO_2/O_2 concentrations in large egg masses on hatching times is outlined.

INTRODUCTION

The vicinity or interior of termite mounds is used by several reptiles and birds as nesting sites. Termite mounds are known to have relatively high and stable internal temperatures (Watson and Abbey 1986). Magnusson (1989) reported that Schneider's Dwarf Caiman in the Amazon jungle builds its nest alongside a termite mound to utilise the higher-than-ambient termite mound temperatures. Perez-Higareda & Smith (1989) reported that the Mexican Colubrid snake *Adelphicos quadrivirgatus* laid its eggs into termite nests for incubation.

The use of termite mounds for egg incubation has been reported for the Tree Monitor *Varanus varius*, by Cogger (1967, p60) and the Kangaroo Island Heath Monitor by King and Green (1979). Longley (1945) reported *Varanus varius* eggs from a termite nest high in a tree, and Cowles (1959, p173-7) describes the oviposition, hatching and early life of *Varanus niloticus*

in termite mounds in Natal. Some birds (eg paradise parrot, golden shouldered parrot and some kingfishers) are known to nest in termite mounds (Simpson and Day 1989). Termite-mound inhabiting geckos of the genus *Gehyra* in central and northern Australia lay their eggs into ventilation chambers and shafts in mounds. Terrestrial geckos, skinks and snakes similarly utilise subterranean termite nests in far Western Australia (H.E. pers. obs.).

In February 1988 one of us (Brendan) saw and video-taped a Heath Monitor digging a hole into a termite mound in the family's backyard at St Ives, and it subsequently laid eggs into the hole. Soon after this Gerry and Harald became involved, and in collaboration with Geoff a monitoring system for the nest was developed. This system included measuring probes and microphones inside the mound with a data logging and recording system in Brendans's house, as well as a telephone hook up to a radio-pager system. This pager system was intended to give the first warnings of either hatching or significant disturbance by an adult monitor digging into the mound.

Here we report the observations made in and since February 1988 and also discuss some of the implications for our understanding of development and hatching rates in reptile eggs.

MATERIALS AND METHODS

Opportune observations (with photographic recordings) and regular monitorings were made at select times to March 1991, particularly during the warmer months. We developed monitoring systems for temperature (precision thermistors) and sound (solid state crystal microphones) at the eggs, and nearby (= Control, 12cm from eggs) as well as a gas probe that allowed repeated/regular measurement of respiratory gases and humidity in the mound within 2 to 5mm of the eggs. The systems were inserted into the mound in the vicinity of the eggs by using a specially designed corer that minimised mound damage, or they were repositioned soon after the eggs were laid while the loose sand backfill (scratched in by the monitor) could still be extracted with a vacuum cleaner.

The monitoring system consisted of three thermistors and two piezo-electric vibration transducers. The thermistors were connected through a switch box directly to an ohm meter and then a standard curve was used to convert the resistance to a temperature.

Piezo-electric transducers were chosen due to the nature of their operation and construction, being more suited to the enclosed, humid environment of a termite mound. Being a device dependent on crystal deformation by shock waves to produce a corresponding voltage, they necessarily required close contact to the eggs. The connections to the devices were sealed with an epoxy-based compound.

Two sensors were used, each being amplified through a balanced amplifier and the resultant outputs subtracted for alarm purposes. In this case one sensor was placed in contact with an egg and one at 12cm from the eggs still within the core of the mound. Under normal circumstances the difference is essentially zero. However, should movement occur at the egg or near it, a difference signal is detected and used to trigger an alarm and a radio pager system.

An interval timer (1/2,1,2 and 4 hours) was also incorporated into the unit to allow a few minutes recording onto a stereo tape recorder at each interval. The core nesting chamber of the termite mound was on one occasion exposed by cutting out a large segment of the conical nest with a long-bladed two-handled log cross'cur saw. After examination, photography and sampling (20 minutes) the segment was replaced and within a week the termites had concealed all surface damage.

OBSERVATIONS AND RESULTS

Nesting, Clutch Size and Early Protection of Nesting Site

Nest digging was seen twice: once in mid February 1988 and once in early March 1990 by one or possibly two different females of about SVL 350mm (Total 915mm) and weight (after laying) of about 700g. The digging female was on both occasions accompanied by another, slightly larger and more wary Heath Monitor which stayed nearby while digging occurred. It is not known whether digging was shared or whether the companion was male or female.

The holes were between 45 & 55cm deep from the upper part of the curved side of the mound into the core of the termitarium (see Fig. 1.). These holes were very narrow in the harder parts of the mound so that the digging female had to compress herself to get through. The burrow tailings from the flaky inner core probably fell into the adjoining termite galleries.

T1= thermistor at egg surface
T2= thermistor at control point 12cm from T1
T3= thermistor in outer wall
M1= microphone at egg surface
M2= microphone at 12cm from M1

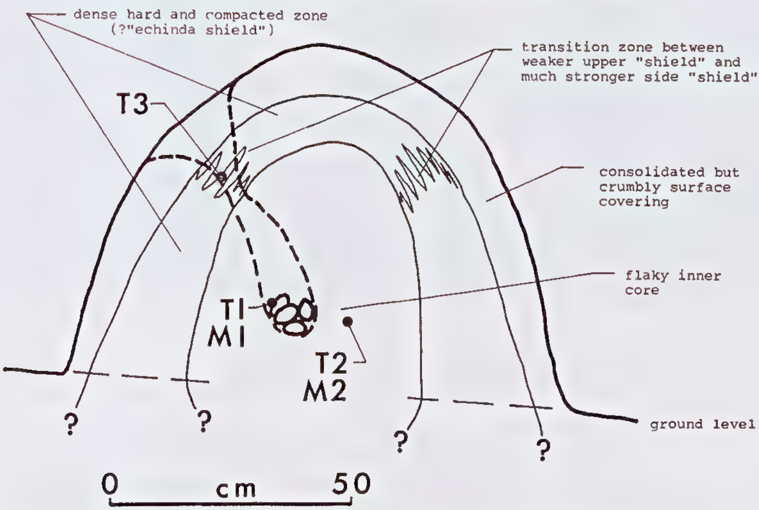


Figure 1. Termite Mound Hardness and Texture Zones, Heath Monitor Oviposition Site and Sensor Placement

The path of the burrows cut through the weakest points of the termite mound (Fig. 1) and the diggings took 2 to 3 days and continued through into the night, as least as late as 10pm on one occasion. The base of the nesting burrow was in the warm nesting area of the host termites *(Nasutitermes exitiosus)* where the substrate is softer and more flaky, and the monitor(s) scratched out a slightly enlarged chamber.

While placing the sensors into the mound in July 1988 we found six partly disintegrated egg cases (see Fig. 2) that were well embedded in the cement-like termite mound matrix before we reached the four viable eggs that had been laid the previous February. These six eggs were two different sizes, shell thickness and discolorations. Subsequently all were found to contain skeletal fragments that later were matched by x-ray comparison with a hatchling Heath Monitor. Thus at least two other clutches (of at least 3 eggs each) had been laid in the mound in most likely one or possibly more earlier seasons (possibly one female with two clutches in one season, two females in one season or less likely in two separate earlier seasons).

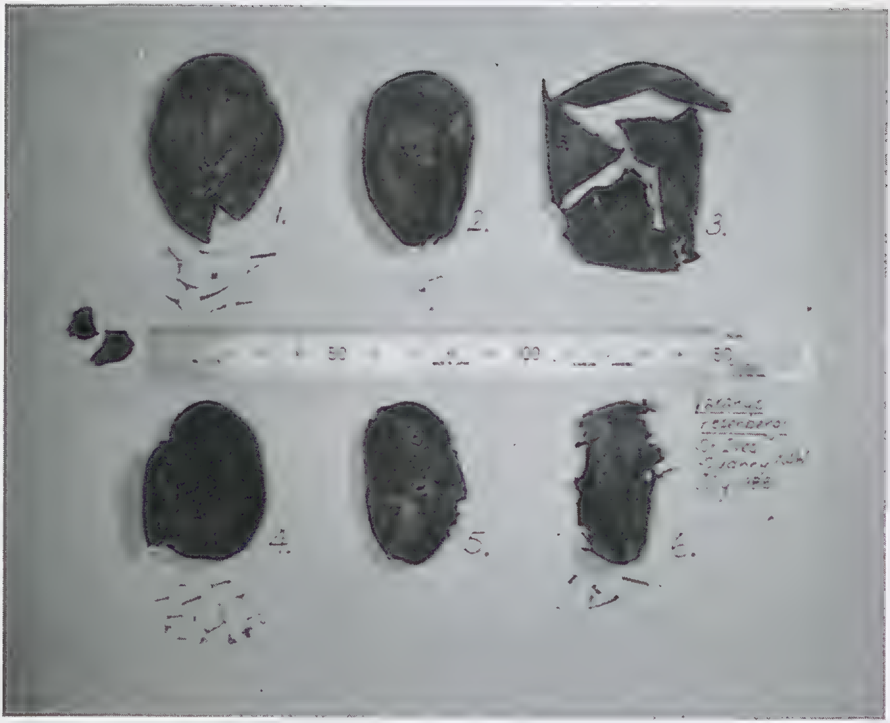


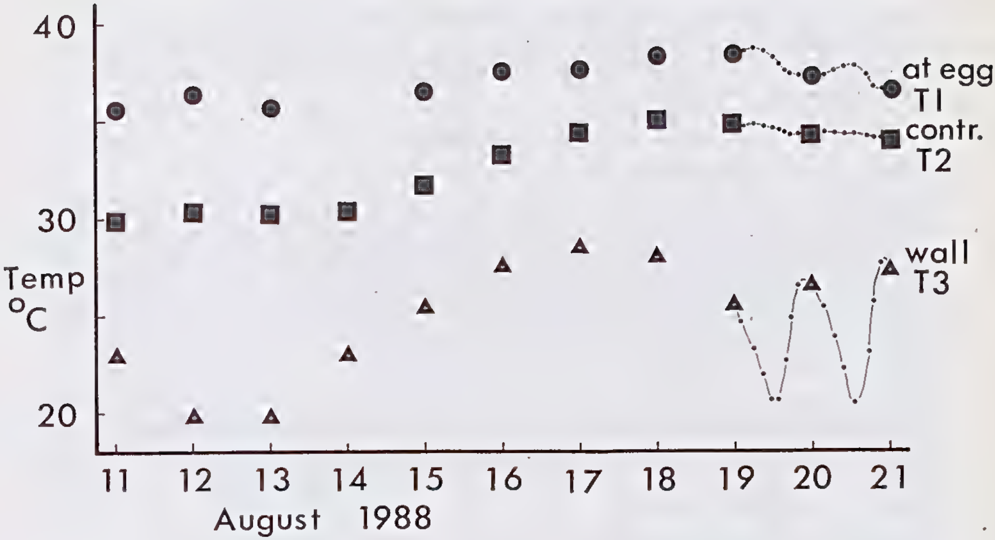
Figure 2. Six Eggs and Associated Bones found in Termite Mound Incubator used by a Heath Monitor at St Ives, Sydney, July 1988.

The two observed layings yielded 4 eggs (1988) and at least 3 eggs (1990) respectively. These eggs were surrounded by or completely covered with soil scrated by the nesting female from the upper sides and crown of the termite mound. These scratchings of coarse sandy particles (together with a small but significant proportion of fallen leaves, small twigs and gum nuts) lay uncompacted around the eggs and in the burrow. The termites began to reconstruct the mound within 2 days so that after 3 to 5 weeks the nesting holes and associated scratchings were completely covered. However the interior reaches of the nesting holes continued to retain traces of leaves, twigs and pockets of sandy soil within the termite mound matrix for at least six months.

For between 2 and 5 weeks after laying, the monitors (the digging female and her companion) foraged and sheltered in the general vicinity of the nesting mound.

Incubation Events and Conditions

While the eggs are still surrounded by the coarse sandy backfill and further covered by the termites' initial repair material (rather loose) they are subject to high humidities (a feature of the mound's interior) and increased CO_2 levels (see later). In this hydric environment they absorb moisture and one egg is estimated to have increased its volume by 75% within (at most) five months. In mid July 1988 when this egg was exposed it was accidently ruptured during sensor placement. The embryo was fully developed and very tightly coiled and compacted in the egg case with about 25% of the egg's volume taken up by a large yellowish



The dated points are 16h30 readings, with daily variations plotted during 19-21 August.

● at the egg' surface = T1 in Fig. 1
■ at the control point = T2 in Fig. 1
▲ in the outer wall = T3 in Fig. 1

Figure 3. Temperatures in a Termite Mound Incubator used by a Heath Monitor at St Ives, Sydney, 1988.

yolk sac. The two eggs seen at this time were tightly adpressed and cemented into the termite galleries with no possibility of expansion, and both expanded and bulged out of their entombment when first partly exposed.

The temperature of one egg (measured at its surface) and a control point (about 12cm distant within the mounds inner core) was monitored at various intervals and times to assess hourly, daily, weekly and monthly variation. Some of these results are summarised in Fig. 3. The egg temperatures remained relatively stable in the long term (range 33.3 to 38.6°C mean 36.2, n=95, all months). The CO_2 levels in the vicinity of the eggs were also high (range 9670 to 14000 $\mu l/ml$, mean 11650, n=5) and the relative humidity never fell below 92%.

Hatching and Emergence of (or release of) Young

Hatching and emergence has not yet been observed in this study. In mid November 1988 a Heath Monitor that looked very similar to one of the two that visited in February spent about a week in the vicinity of the mound without digging into it. Then again in mid February 1989 the same monitor spent about two days in the area but it may have been scared off by our presence. At the time we restricted our observation efforts so as not to handle the animal or come nearer than about 4 or 5 metres.

In late May 1989 we cut into the mound to check the eggs laid in February 1988. All three remaining eggs had died some time before and had been invaded by termites. They had deteriorated slightly more than those shown in Fig. 2. X-ray imaging of the remains showed bones of young that were as well developed as the sibling young in the accidentally ruptured egg removed in mid July 1988. The bony remains (mostly distal and caudal vertebrae, skull

fragments, large limb bones and girdles) in all recovered dead eggs were entirely located within the lumen of the egg-shells' remains, indicating that none had made a successful exit from their entombed egg. All egg shells were too decayed to assess whether they had been slit (total of 3 clutches and 9 eggs).

DISCUSSION

Nesting, Clutch Size and Early Protection of Nesting Site

The mound of this termite species has an extremely hard internal shield and the structure is almost impenetrable (Fig. 1, pers. obs.). The monitor nesting burrows were dug in a way that suggests the behaviour is instinctive and a frequent nesting/oviposition behaviour. Just how advantageous is termite mound nesting? In this study at least 9 eggs in 3 or 4 years did not hatch which suggests that (in this case at least) this incubating method is not very effective. It is possible that the proximity of suburbia and regular human activity disturbed the adult monitors' caretaking and opening of the nest (see below).

Lingering of the monitors after oviposition for 2 to 5 weeks may have been to protect the laying site until the host termites repaired the damaged mound. Echidnas are known to occur in the area and the Heath Monitor's nesting burrow would provide them ready feeding and sheltering access into the termite mound - an echidna's rummaging and feeding in a termite mound would certainly damage monitors eggs.

Incubation Events and Conditions

Parchment-shelled reptile eggs generally continue to increase in size and also change shape (becoming proportionally fatter) during the course of incubation (H.E. in prep). The eggs of the Heath Monitor laid into the termite mound were completely constrained by the rebuilt surrounding termite gallery material within (at most) five months of laying. The constriction on egg expansion imposed by the termited means that the developing egg probably has an atypical water uptake and the embryo is relatively tightly packed. The initial uptake of water required by the eggs/embryos must be rapid enough to beat the limiting enclosure by the termites' more or less permanent repair work around the eggs.

How Do the Young Hatch and Escape the Mound?

The claws of the hatchling are relatively feeble and seem too weak to scratch an escape passage through the gallery walls and harder, denser cement-like shielding around the mound's nesting chamber. However the residual egg fluids may aid in softening the termites galleries (see Cowles 1959, p174-5 for a description of how hatching Nile Monitors leave their termite mound incubator without parental assistance). The movements that such a small animal (SVL 92mm Total 227mm, weight 11.1g) would have to make in tunnelling out would attract probably overpowering attention from the hordes of soldier termites that gather at even small mound disruptions. It is possible that a sticky, wet coating of residual egg fluid protects the hatchings from the soldier termites' chemical defences. The maximum cross sectional area of any termite gallery is at least 3 times less than the largest cross-section of the hatching monitor, so it could not simply utilise existing galleries to escape.
King and Green (1979) found that Heath Monitor eggs on Kangaroo Island did hatch soon after being exposed or removed from their termite mound.

It may be that young (hatching) Heath Monitors are totally dependent on an adult (probably a nesting female and likely the parent) for their release to life outside the nest (based on three fully developed, unreleased and dead egg clutches). It is most unlikely that a female would deposit her eggs into a termite mound and leave the subsequent release of her progeny to chance: the more likely event is that she or her companion returns to release them. The long persistent plant fragments that remain in the mound as a witness to nesting by a monitor may also help to guide a liberating adult to the entombed young.

We hope to observe adult or parental release of the young and any associated behaviours in the imminent warm season.

Incubation Rates and Hatching/Emergence Times

The relatively high and stable temperatures and humidities within the termite mound are conditions not unlike those present in many successful and presumably ideal artificial set ups for incubating reptile eggs.

Artificial incubation times for the Lace Monitor range from 153 to 317 days (Bredl & Schwaner 1983, Markwell 1983), and for the Sand Monitor from 169 to 265 days (Barnett 1979, Irwin 1986). These incubation times are extremely variable. One measure of this variability can be calculated as follows: $(\ell - s)/s$ where ℓ is the longest known incubation time, s is the shortest incubation time and the result is a variability index. Thus the respective hatching time variability indices are Lace Monitor (*V. Varius)* 1.07, and Sand Monitor *(V.gouldii)* 0.57.

The incubation times for some other Australian reptile species have been determined artificially and the effect of temperature on incubation rate has been well demonstrated (see for instance Legler 1985 and also Limpus et al 1985). The published artificial incubation times typically have a hatching variability index of up to 0.4 in the 27-32°C temperature range. The incubating systems in wide use are sufficiently open to ensure that respiratory gases CO_2 and O_2 remain at or near atmospheric proportions.

Natural incubation sites chosen by reptile females are often more closed and respiratory gases vary significantly from atmospheric or artificial incubating systems (Seymour & Ackerman 1980; and for example the many reptiles that dig nesting chambers in compact or dense soil). The effect of increased CO_2 decreased O_2 in retarding incubation rates in reptile eggs was outlined by Packard et al (1977 p87,94). The eggs of the Heath Monitor, as well as those of the Lace Monitor and Sand Monitor, are all laid in relatively sealed nesting sites where CO_2/O_2 balance is significantly altered from atmospheric.

The CO_2/O_2 balance and its natural variability may account for the high hatching time variability for reptile eggs that are buried or laid into mounds (see above). A sudden shift to near atmospheric CO_2/O_2 balance (as occurs when read-to-hatch eggs are exposed) may trigger hatching.

Uniform Development and Synchronous Emergence of Reptile Hatchlings from Large Egg Masses

Packard et al (1977,p89) state "Since eggs in the centre of a sea turtle nest must undergo incubation at a slightly higher temperatures than are experienced by eggs at the periphery, it is reasonable to assume that development of centrally located eggs is completed before that of other eggs in the nest." It is also probable that lower oxygen levels around and in the central eggs retard development, thus counter balancing the effect of increased central temperatures on development rates.

Despite this probable tendency to equalise development rate, it seems unlikely that this accounts solely for synchronised emergence in turtles (see also Prange & Ackerman 1974).

ACKNOWLEDGEMENTS

We thank Ian and Rhonda Smith for their support, assistance and encouragement.

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ON THE EFFECTS OF CROWDING AND POLLUTION IN TADPOLES OF THE BROWN-STRIPED MARSH FROG *(LIMNODYNASTES PERONI)*

Merinda Voigt
682 Old South Head Road
Rose Bay NSW 2029

ABSTRACT

Tadpoles of the Brown-striped Marsh Frog, *Limnodynastes peroni*, were reared under different conditions of crowding and of water composition. Neither filtration with activated carbon nor regular water changes make any difference to the growth stunting effect of crowding. The tadpoles gained only 5% of the body weight of an uncrowded control group, regardless of whether they were both polluted and crowded or crowded only.

Furthermore, the effect of poor water quality (simulating agricultural pollution) on growth of uncrowded tadpoles is similar to that of crowding. Growth is retarded when either or both inhibiting conditions exist and only begins again (after a delay) when both conditions are alleviated.

Tadpoles of *Limnodynastes peroni* may have evolved to grow very slowly when crowded in shrinking puddles, gambling on rain to come in time so that the greatest number of siblings can survive. They use the same mechanism when confronted with agricultural pollution. The result is that many miss out on the next breeding season. They are aging tadpoles when they should be frogs.

The maintenance of tadpoles in small bare containers was improved by ammonia-absorbing ion exchanger resin pads. The results also include some data on toxicity levels of potassium nitrate, sodium chloride and of chloramine-treated tapwater.

INTRODUCTION

This paper is the outcome of part of my work for the Advanced Herpetology course, run at Sydney Technical College by Harry Ehmann.

Detailed experimental data and consideration of alternative explanations are recorded elsewhere (Voigt, 1989).

The subject species was *Limnodynastes peroni*, the Brown-striped Marsh Frog, a terrestrial species which prefers permanent water sources. It ranges from the eastern Queensland coast down NSW and Victoria, also occuring in Tasmania.

About 1000 eggs are laid in a foam nest. Each egg is black above, serving as protection against ultra-violet rays (Tyler, 1989). Usually these eggs are laid in sunlit water, although I have found the frogs breeding in the deep shade of my backyard, in winter as well as summer.

Crowding is a natural and common condition for tadpoles as these frogs are prolific and have access to mainly small volumes of water. Nevertheless, tadpoles react to each other's company by growing more slowly (eg. Sokol, 1984).

It is not known why crowded tadpoles grow very slowly and metamorphose later (Tyler, 1989). Many theories are given; one of them proposes that tadpoles secrete a substance that stunts them and through which they can effect each other when crowded (Wassersug and Karmazyn, 1984).

Tyler (1989) states that in Australian only one study on tadpole crowding has been documented (Sokol, 1984, *Litoria ewingi*). Sokol demonstrated that crowded tadpoles grew more slowly and

took longer to metamorphose. He concluded that these effects were caused by unknown substances released from the tadpoles, and not by behavioural interaction between them.

Overcrowding of fish fry also leads to stunting. From my observation, this is especially the case with gouramis. Like frogs, gouramis are also able to lay a large number of eggs (i.e. many siblings) in small volumes of water (i.e. crowding) in which other fish cannot survive.

METHODS AND RESULTS

Experiment 1 (Crowding with and without activated carbon)

The tapwater in my area contains up to 0.5mg/ℓ chloramine (John Ericson, Ryde Laboratories, Water Board). I removed the chlorine component with aquarium dechlorinator. The ammonia which was liberated by the dechlorinator's action on the chloramine was removed with commercial "Ammo Pad" ion exchanger (Aquarium Pharmaceuticals Inc.). I had found earlier that removal of the chlorine only is not sufficient. To be certain that the water was properly conditioned, I aerated it in a large storage container and also kept a bunch of aquatic plants (Cryptocoryne) in it for a few days.

For Experiment 1, three identical aquaria were equipped with undergravel filters (occupying the entire floor space) and with two airlifts each. The gravel was partly sterile and partly from an established aquarium, containing nitrification bacteria. A layer of activated filter carbon (Wardley's M & T Grade) was sandwiched in the undergravel filter of one aquarium.

The purpose of the biological filtration was to remove metabolic ammonia and nitrite and also to allow the resulting nitrate to accumulate (instead of being lost as nitrogen in pockets of anaerobic activity). The purpose of the chemical filtration was to remove any organic secreted substances.

Each tank was filled with 11 litres of conditioned water. As tadpoles need ultraviolet light for their jawbone development (Tyler 1985), a 40W Biolux B fluorescent tube was placed evenly over all three tanks and was switched on for 14 hours per day. The tanks were unheated, their temperature ranged between 15 and 19 degrees but was the same in each tank at any particular time.

All tadpoles were from a single foam nest of at least 1000 eggs. During the first two weeks of their lives they were kept outdoors in uncrowded conditions (a 500 litre pond) at between 6 and 11 degrees. By this time they were large enough not to be sucked into the undergravel filter and were used for the experiment.

The uncrowded tank was stocked with ten tadpoles; the others received 260 tadpoles each. All tadpoles were of the same size (9mm) and were acclimatised to the conditioned water over two days.

The tadpoles were fed abundantly with crushed fresh lettuce and wholemeal bread, with old food removed daily. They were also given small amounts of flaked tropical fish food.

The pH fluctuations were gradual and similar for the three tanks. Near the end of Experiment 1, the pH had risen to 7.9, 7.9 and 8.0 and was then adjusted back to neutral with similar amounts of phosphate buffer over two days.

During and at the end of Experiment 1, a two stage measuring process was used. I firstly selected an average tadpole and then measured it in the hand to the nearest millimetre. This was repeated several times to gain accuracy.

Experiment 1 was discontinued after 43 days when the growth pattern had become obvious.

I expected the tadpoles with the activated carbon to grow as well as their siblings in the uncrowded control tank.

These results were unexpected. In the time it took the uncrowded tadpoles to grow to a total length of 40mm, the crowded ones in the identical tank, as well as the crowded ones in the tank with carbon filtration, only grew to 16mm in length (Fig. 1).

Any organic growth inhibitors secreted into the water probably would have been removed by the carbon. However, the carbon filter made no difference to their growth.

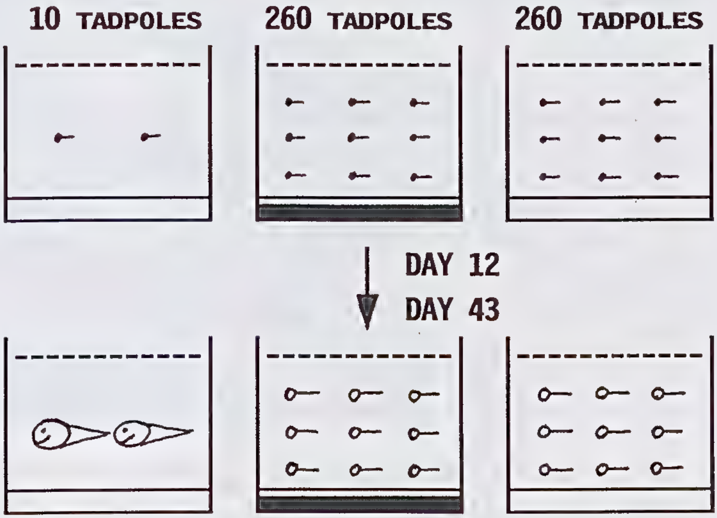

Figure 1. The tank in the middle is the aquarium with the carbon filter. This experiment showed that crowded tadpoles with activated carbon filtration grew at the same rate as crowded tadpoles without filtration.

Experiment II (Crowding with regular water changes)

I then removed everything that could have gone through the carbon filter, through daily partial water changes in that tank. This should remove a build up of any secreted as well as excreted waste products. To my surprise, it made no difference to their growth either.

The 10 uncrowded tadpoles kept growing well, the ones in the two crowded tanks did not - regardless of whether they were in clean or polluted water.

By the conclusion of this experiment, most of the ten relatively uncrowded tadpoles had metamorphosed - at 56-60mm length. Crowded tadpoles reached only an average of 22mm length, regardless of whether they were still in old water or in water changed regularly.

Figure 3 show what happened to the average sizes over the course of the experiment. The control group in the uncrowded tank grew much faster and metamorphosed earlier. Although the degree of stunting in the increasingly polluted crowded tank and in the clean crowded tank is almost the same, the size distribution at the end of the experiment does show a difference (Fig. 4).

The yield in tadpole biomass per tank was about the same. The average uncrowded tadpole weighed 20 times as much as the average small one, being nearly three times as long and of similar proportions. However, there were 20 times as many tadpoles in each of the crowded tanks (a bit less for the polluted tank though, because of the higher losses).

Figure 2. An average -sized crowded tadpole of 22mm total length and an average uncrowded one of 59mm. Both are 111 days old. The smaller tadpole could have been from either of the two crowded tanks (the clean or the polluted one). The large tadpole is from the uncrowded control tank.

Experiment III (the effect of pollution on uncrowded tadpoles)

By a process of elimination, I chose nitrate as the most likely suspect among metabolic waste products. Ammonia and nitrite readings were extremely low and no worse than in the uncrowded control tank; phosphate was used as a pH buffer and was therefore high in all three tanks - without ill effects on the control group; potassium has no reputation for toxicity (NH&MRC, 1987). Many aquarists believe that nitrate causes problems when fish are crowded (eg. Jenno, 1985).

I set up three plastic containers, each with a water volume of 3 litres but with varying measured amounts of potassium nitrate. In addition, one container (A) had no nitrate added to its conditioned water (but gained some 25mg/l nitrate during the experiment). A second control container (E) had a table salt solution one tenth as strong as seawater (Fig. 5).

The weak nitrate solution (B) started off within nitrate limits for drinking water. The European legal limit is 1.7 times higher (Saull, 1990) and the Australian guideline limit 1.5 times higher (NH&MRC,1987). B marginally exceeded this limit by the end of the experiment. C contained ten times as much nitrite and D ten times as much again. D has the same salinity and osmotic pressure as E.

Over the course of eleven days, three previously crowded tadpoles were acclimatised into each of these five solutions. Firstly their tank water was replaced by fresh, conditioned water over two days. Then, concentrates were pipetted into their containers twice daily over nine days.

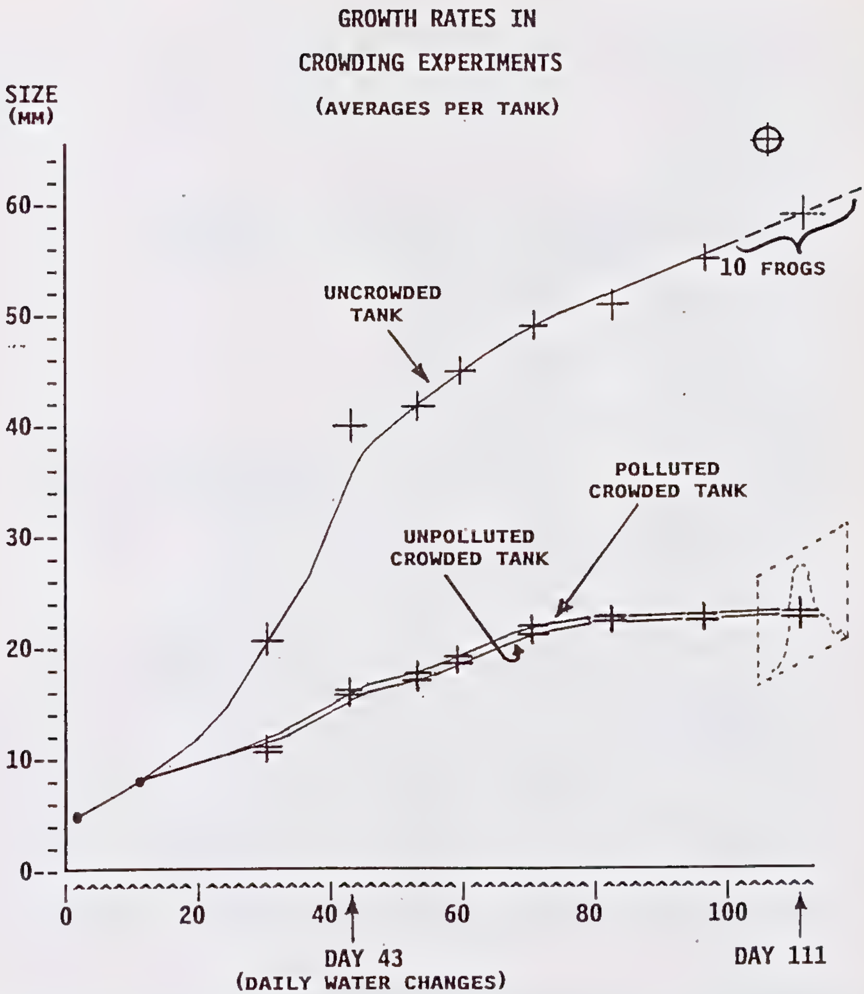

Figure 3. Growth in the uncrowded and in the two crowded tanks. (The separate data point at the top right represents a single sibling raised by itself - totally uncrowded. It became even larger and metamorphosed even earlier than the others.)

As the containers lacked gravel or leaves for nitrifying bacteria to grow on, I had to eliminate the metabolic ammonia in a different way. Ammonia is very poisonous to tadpoles if allowed to accumulate (Tyler, 1985). I kept a small "Ammo-pad" in each container and recharged it every second day.

The four graphs in Fig.6 track the fate of all specimens in the experiment. They show that after a delay, some of the individuals in container A and B resumed rapid growth. In containers C, D and E there were fatalities and relatively minor growth.

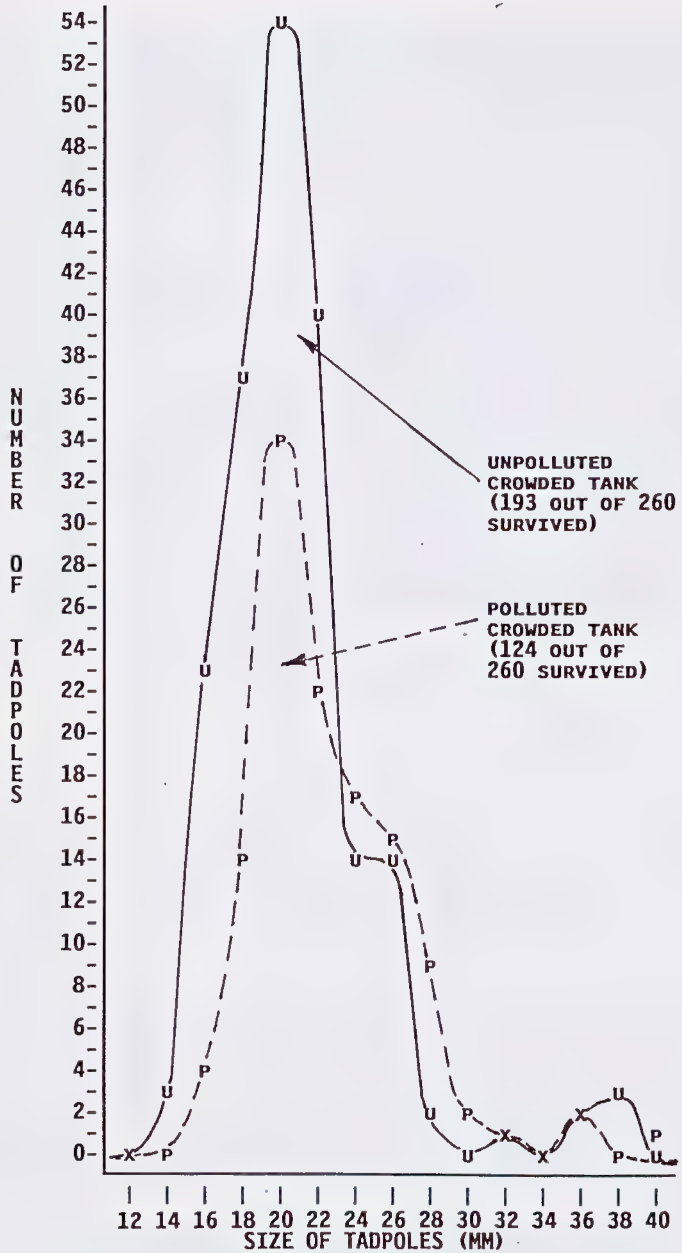

Figure 4. The total length distribution of the two crowded populations at the end of the experiment.

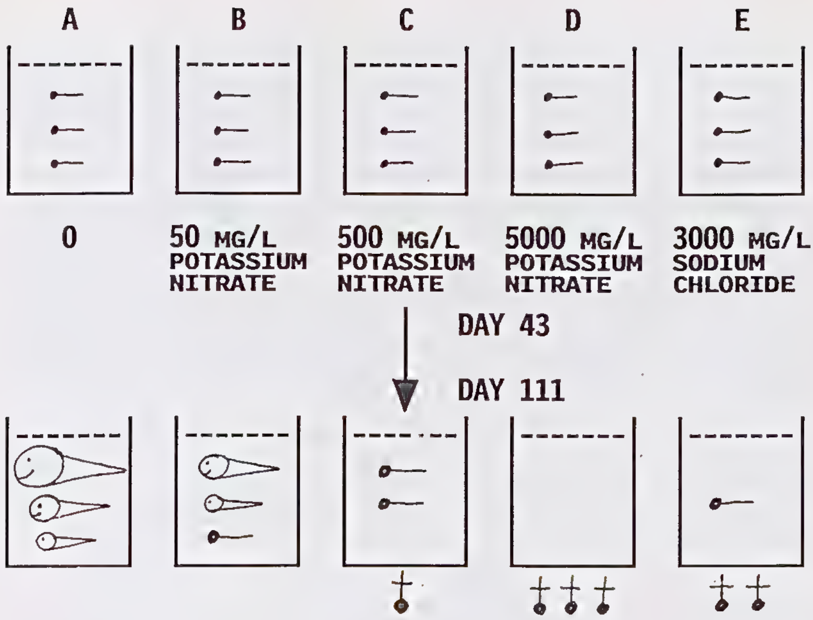

Figure 5. Experiment III with different levels of nitrate and with two control groups.

I now plotted the average growth rates in each of these containers and compared them to the growth rates of the crowding experiments. (Statistically this is not directly comparable because only 3 x 5 individuals were involved. However, the nitrate curves do follow a consistent pattern.) The comparison shows a number of interesting aspects (Fig. 7).

The tadpoles at first did not grow after they were moved out of the crowded tanks and acclimatised into their solutions. Even those moved to the clean control container (A) took several days to resume growth.

Secondly, the growth rate in the stronger solutions (if they survived) was about the same as in the two crowded tanks. Tadpoles clearly have a slower growth rate when either crowding or pollution or both occur.

DISCUSSION

Firm conclusions cannot be drawn because of the low numbers involved in the nitrate experiment. However, even with these low numbers, some trends are evident.

For these tadpoles, it could be that:

1. They reacted to stress inducing conditions (crowding, pollution) by switching their energy from growth to the demands of the immune system. This may be a suitable strategy for this species of tadpoles because crowding is a frequently occuring condition for them. A boost to the immune system would help them withstand crowding without risking epidemic infections.

2. They switched to a slow, energy conserving growth rate. This would also suit them under natural crowding conditions, ie. growth could be suspended to conserve resources, to make them last until conditions improve.

I do not wish to discuss the immune system further here. Regarding resource conservation: crowded *Limnodynastes peroni* tadpoles may conserve their food supply and their water quality, for the good of the whole (and at a sacrifice to each individual), so that the greatest number of siblings survives if conditions improve again as is likely to occur in the regular rainfall areas this species inhabits. Such cooperation would be an alternative strategy to the selfish race for resources seen in other species eg. *Lechriodus* (Cogger, 1986).

R. Dawkins (1982) writes about the "selfish gene" and about natural selection pressure not working on the survival of the species nor even of the individual, but on the survival of competing genes, sometimes at the expense of individuals.

Crowded tadpoles would thus conserve their own and each other's food supply and water quality, so that the greatest number of siblings survives if it rains again. Large numbers of siblings are often in puddles about to dry up or to run out of food. Siblings tend to have many identical genes. It then makes sense for some to curb their growth so that at least some sets of similar genes can survive.

Dawkins was not writing about crowded tadpoles but they seem to be a good illustration of his point.

Whether the tadpoles employed energy diversion to the immune system or energy conservation cannot be determined from this study. It could be that they employed an optimal combination of the two.

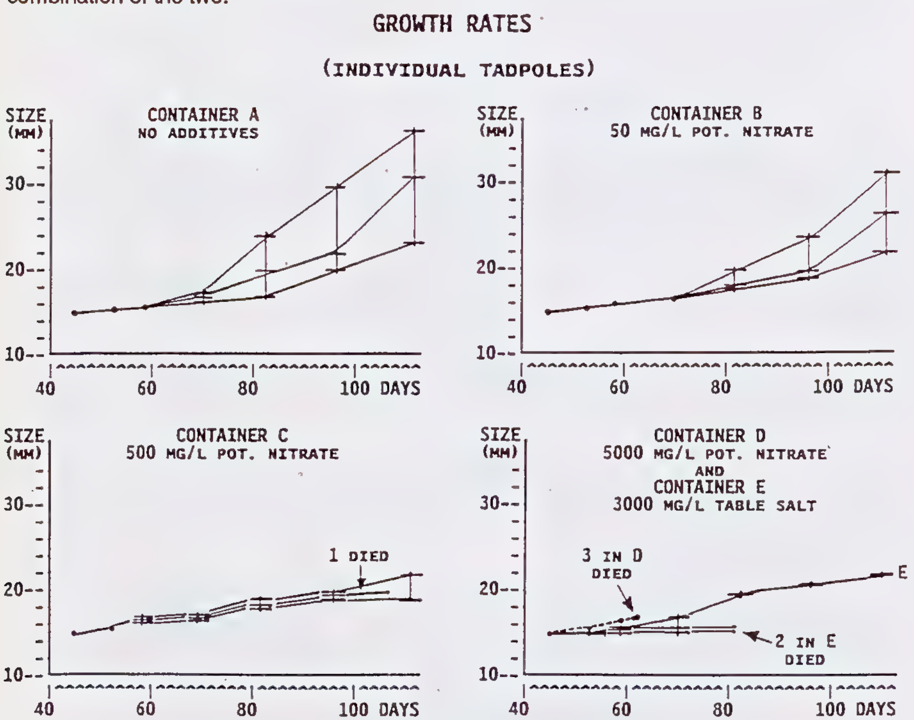

Figure 6. This shows the progress of each tadpole over the course of the experiment. The ones in the stronger nitrate solutions and in the table salt solution could not cope at all: some died, others remained stunted.

The results of my experiments are at variance with those of Sokol (1984). He raised 50 tadpoles of *Litoria ewingi* in a 7 litre tank that was partitioned into two halves by a mesh, with 40 tadpoles on one side and 10 on the other. Sokol found no growth difference and concluded that they retard each other's growth through substances released into the water and not via any behavioural interaction.

Sokol used a bare tank and referred to a fairly high mortality (possibly caused by a build-up of ammonia). If this was the case, his surviving tadpoles would have been sufficiently stressed by ammonia to abandon rapid growth. From this and my data I conclude that tadpoles are also stunted by ammonia polluted water.

There is, of course, a danger in applying findings for one species to reinterpret results for another one.

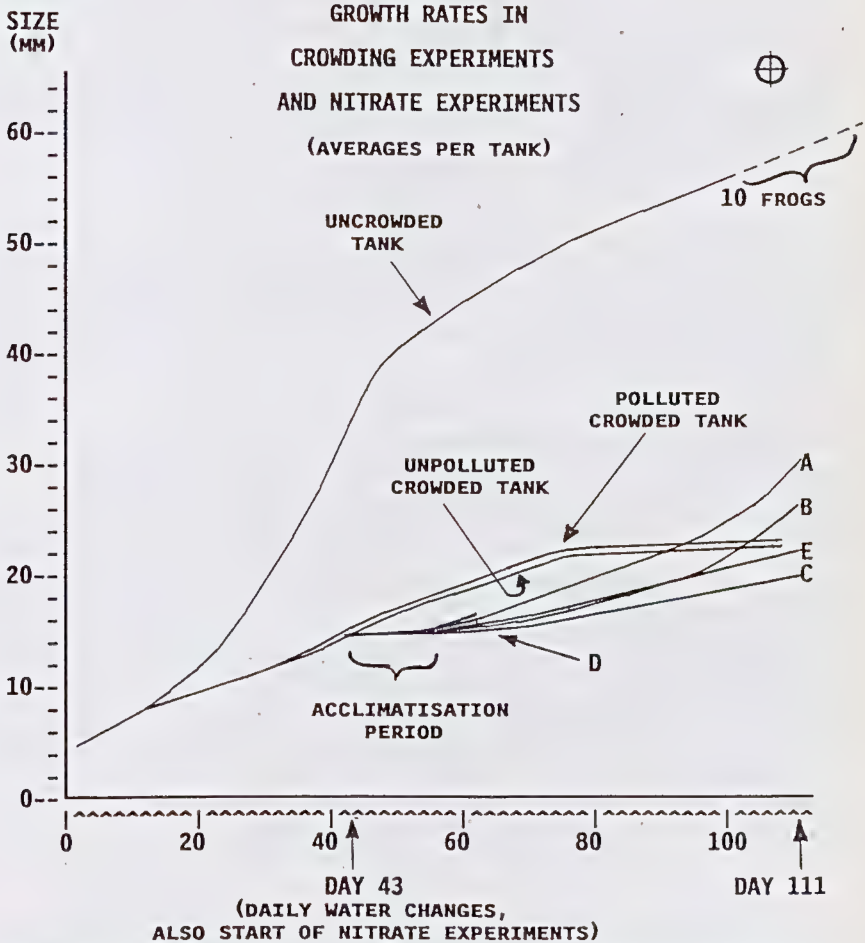

Figure 7. The rate of growth throughout all experiments is shown here, in each case showing the average tadpole size in each tank. Note that the growth rate in containers A and B (with little nitrate) picked up to match that of the uncrowded tank.

CONCLUSION

There is a significant size difference between tadpoles of *Limnodynastes peroni* raised in uncrowded and in crowded conditions. Sokol (1984) concluded that at least in the species *Litoria ewingi*, it is not interaction between the individuals but a dissolved substance produced by the tadpoles, either by excretion or secretion. Ammonia if present in sufficient concentration may be one such substance. Nitrate is a likely candidate, but the exact identity of the substance(s) has remained elusive. If it affects tadpoles only through the water they live in, it must be able to pass through filter carbon and would therefore be more likely to be an inorganic metabolic product or a very simple organic compound. Furthermore, the effect of the substance does not diminish quickly with water changes but appears to wear off over time when tadpoles are transfered to a less crowded environment. It seems that tadpoles that have been retarded in their growth rate had "switched" to a slow growth rate and this cannot be easily reset.

However, indications are that crowded conditions, as well as a heavy burden of waste products and other toxins are stressful to tadpoles; and that they may respond to any stressful conditions by releasing a growth retarding hormone. This would explain the lack of effectiveness of water changes or carbon filtration and it would explain the time lag after crowding has been alleviated. It would then also be in keeping with Sokol's findings, assuming that metabolic ammonia caused the stressful condition which triggered the hormone.

ACKNOWLEDGMENTS

I am grateful for the assistance I received from various sources. In particular, Harry Ehmann and Lothar Voigt provided helpful criticism and discussion of the manuscript. Prof. Mike Tyler and Gerry Swan gave me the encouragement to see this report to its conclusion. John Ericson advised on chloramine and water conditioning. Martyn Robinson provided information on tadpole rearing. I would also like to thank my family for their assistance with layout and their patience.

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A NEW SOUTH WALES RECORD FOR *AIPYSURUS DUBOISII* BAVAY, 1869 (HYDROPHIIDAE)

Steve Phillips, NSW National Parks and Wildlife Service
PO Box 91, Alstonville NSW 2477

True Sea Snakes (family Hydrophiidae) are represented in Australian waters by twelve genera and twenty nine currently recognised species (Cogger, 1983). While the majority of these species occur in tropical waters off Queensland, Western Australia and the Northern Territory, two of them, *Hydrophis elegans* and *Pelamis platurus*, are regularly recorded from waters off the New South Wales coast, the latter species in particular having also been recorded from as far south as Tasmania and the North Island of New Zealand (Cogger, 1983; Heatwole, 1987).

On 7th March, 1991, a local fisherman, Mr Ron Spencer, presented a Sea Snake for identification at the Alstonville office of the NSW National Parks and Wildlife Service. The specimen had been collected from Patches Beach (Latitude: 28° 57'S Longitude: 153° 31'E) approximately 12 km south of the coastal township of Ballina on the north coast of New South Wales. Subsequent morphological examination determined characteristics described below.

Colouration of the specimen was a uniform dark brown to black both dorsally and ventrally, with the posterior margins of the lateral body scales, ventrals and subcaudals edged with cream. The throat scales were similarly dark brown although edged anteriorly to varying degrees with cream.

The head shields, excluding the rostral and nasal scales, were small and irregular, and the posterior chin shields were separated by a single, small scale. The number of ventrals were 160 (the anal scale and possibly one ventral scale were missing as a result of damage to the cloacal region). The mid body scale count was 19. There were 27 subcaudal scales, all of which were single. The total length of the specimen was 975mm (S/ V length: 860mm; tail length: 115mm). Using the dichotomous keys of both Cogger (1983) and Gow (1989), the specimen was identified as *Aipysurus duboisii*.

A.duboisii is a highly variable Sea Snake distributed in waters of the continental shelf from north-western Australia to the southern fringes of the Great Barrier Reef; the species is also extra limital in New Guinea and the Coral Sea east to New Caledonia (Cogger, 1983). *A.duboisii* is found chiefly in shallow reef waters and is reported to be crepuscular by nature (Gow, 1989; Heatwole, 1987).

Internal examination of the specimen proved it to be a female with two (2) approximately mid term embryos *in situ* amid disproportionately large yolks and other embryonic tissue. This observation is consistent with those of Cogger (1983) and Heatwole (1987) regarding the small litter size of Hydrophiids in particular, but also with respect to the amount of materials devoted to the reproductive effort. On the basis of a nine month gestation period similar to that reported for *A.levis* (Heatwole, 1987), the presence of mid term embryos in March, in this female at least, suggests that a late winter, early spring parturition may have been likely.

There are no previous records of *A.duboisii* from New South Wales waters (Sadlier, *pers comm*) and the specimen described herein has now been lodged with the Australian Museum.

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AN UNCOMMON PREY RECORD FOR THE COMMON BROWN SNAKE *PSEUDONAJA TEXTILIS*

James Roberts, PO Box 64, One Tree Hill SA 5114
Peter Mirtschin, Venom Supplies, PO Box 547, Tanunda SA 5352

Brown Snakes of the genus *Pseudonaja,* have been recorded as feeding on a range of prey items. Shine (1989), records the *Pseudonaja* genus as feeding on frogs, skinks, agamids, geckoes, snakes (inc. *P.textilis*), birds and mammals (inc. rabbits).

Of all the skinks recorded as prey items, the common Shingleback or Sleepy Lizard, *Tiliqua (Trachydosaurus) rugosa* has only been recorded as a prey item in the Western Brown Snake *P.nuchalis* (SA) and the Dugite *P.affinis* (in WA). One of us (P.J.M.) has observed a Peninsula Brown Snake *P.inframacula* regurgitating an adult *T.rugosa* after capture.

We submit evidence here of a 1.96m specimen of a Common Brown Snake *Pseudonaja textilis* from Murray Bridge South Australia preying on an adult *T.rugosa.* The snake was killed by residents of a house in the township and later dissected to determine stomach contents (see Fig.1) The snake was killed on 19th January 1991. The only other prey item of comparable size recorded by Shine(1989) for *P.textilis,* was one record of the species *Tiliqua gerrardi* from Queensland.

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Figure 1. A Dissected Common Brown Snake showing *T.rugosa* in the Stomach Contents

NOTES TO CONTRIBUTORS

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This issue of *Herpetofauna* contains the final papers delivered at the Australasian Conference on Care and Captive Breeding of Reptiles and Amphibians, held 29 September - 1st October 1990. These are published on pages 5 to 34. This conference was organised by the Australian Herpetological Society to celebrate its 40th anniversary. Other papers delivered at the conference were published in the last issue of Herpetofauna.

Because of our commitment to publish papers delivered at the Conference we have accumulated a number of other papers. Some 20 of these are ready for publication and most, if not all will be included in the next issue.

Such diverse species as *Pseudechis australis, Sphenomorphus fuscicaudis, Pseudonaja nuchalis, Laticauda colubrina, Strophurus ciliaris, Hypsilurus spinipes, Pogona barbata, Austrelaps labialis, Diplodactylus conspicillatus, Cophixalus ornatus and Tropidonophis mairii* are included.

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